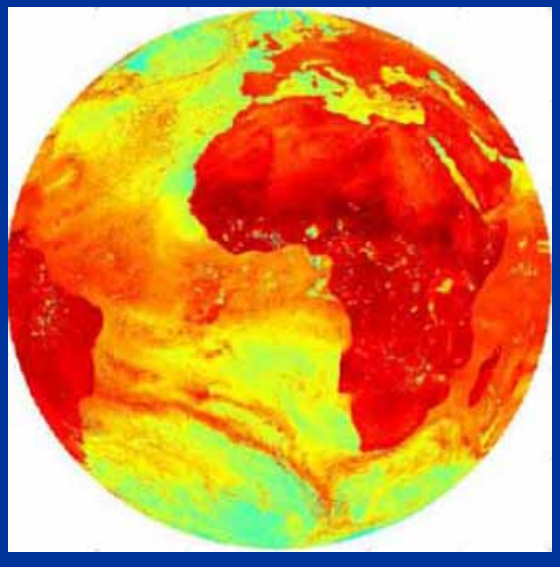
MIT iLabs:
Laboratories Without Frontiers

Jesús A. del Alamo

MIT



4th Annual MIT LINC International Symposium:
Technology-Enabled Education: A Catalyst for Positive Change

October 27-30, 2007

Sponsorship: Carnegie Corp. of New York, NSF, Microsoft Corp.

Motivation to iLabs

- There is enormous educational value in hands-on laboratory experiences
- But, conventional labs…
  - … are expensive and have complex logistics
  - … can't easily be shared
- iLabs: real laboratories that are accessed through the Internet from anywhere at any time

iLabs at MIT

Dynamic signal analyzer *(EECS, deployed 2004)*

Polymer crystallization *(Chem. E., deployed 2003)*

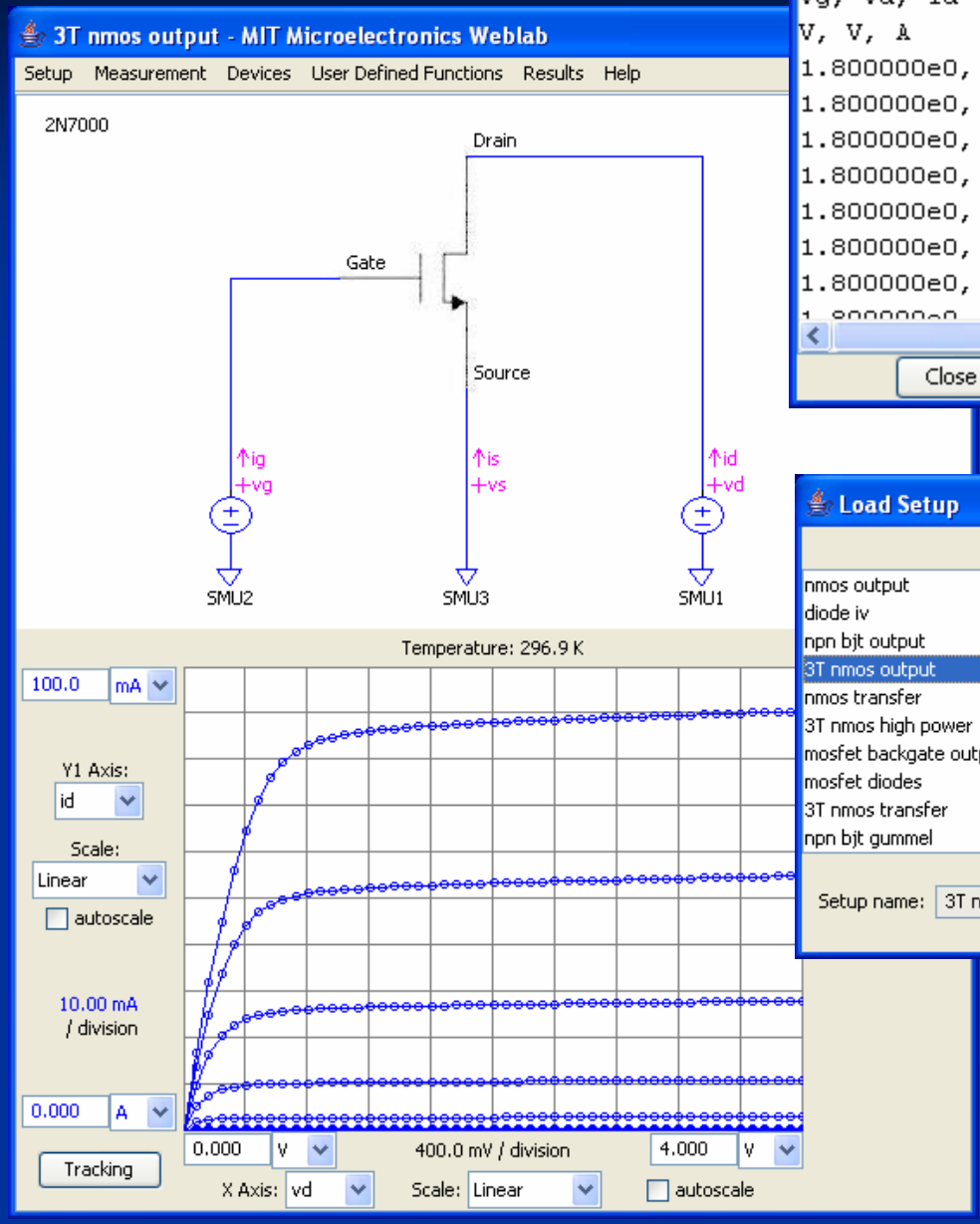
Shake table *(Civil Eng., deployed 2004)*

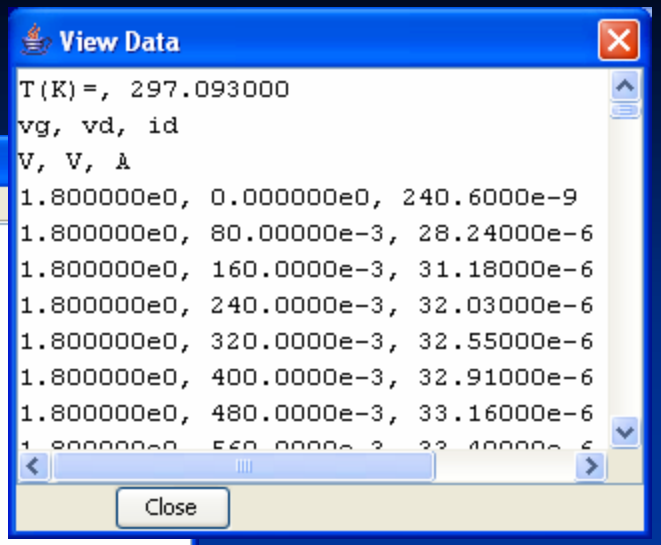
Microelectronics device characterization *(EECS, deployed 1998)*

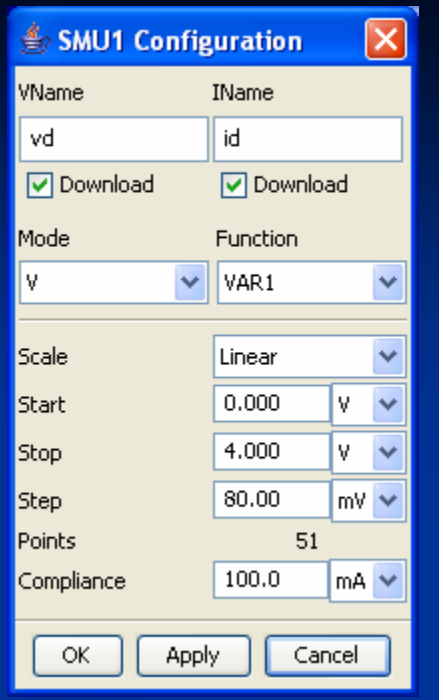
ELVIS *(EECS, deployed 2006)*

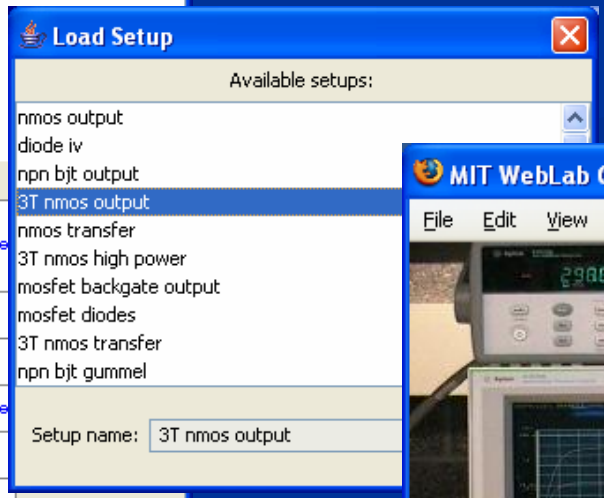
Heat exchanger *(Chem. E., deployed 2001)*

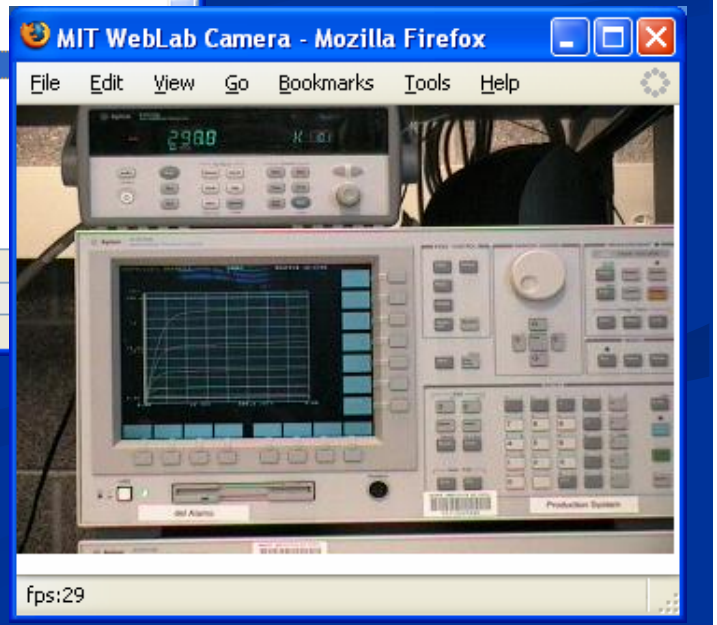
Microelectronics Device Characterization iLab







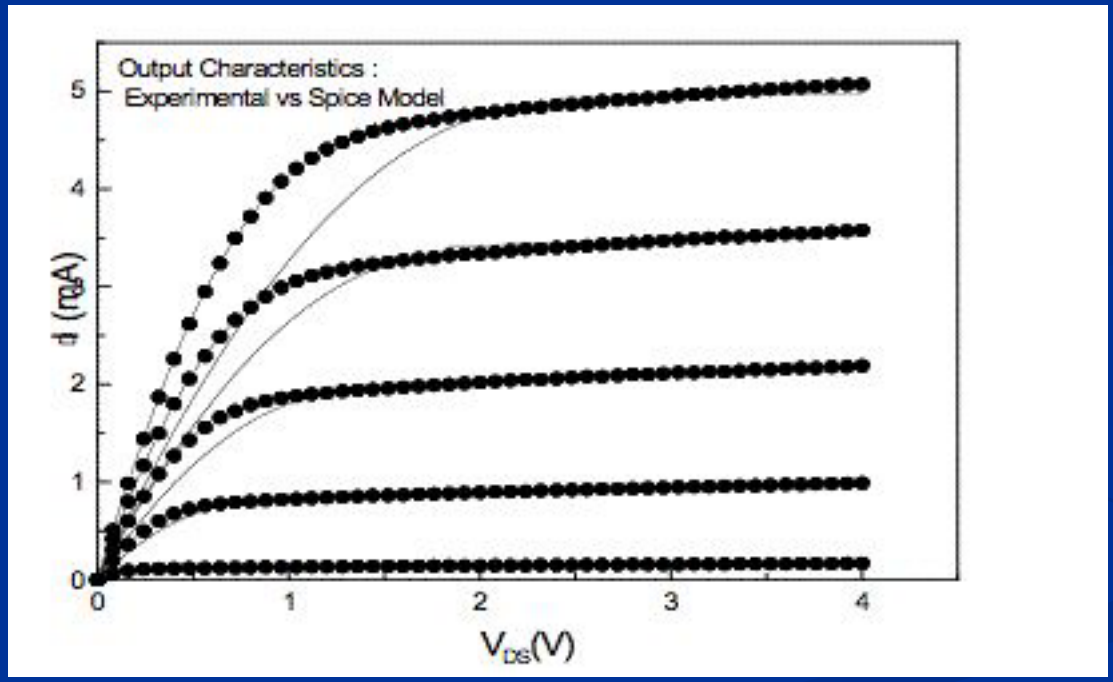




Typical Assignment

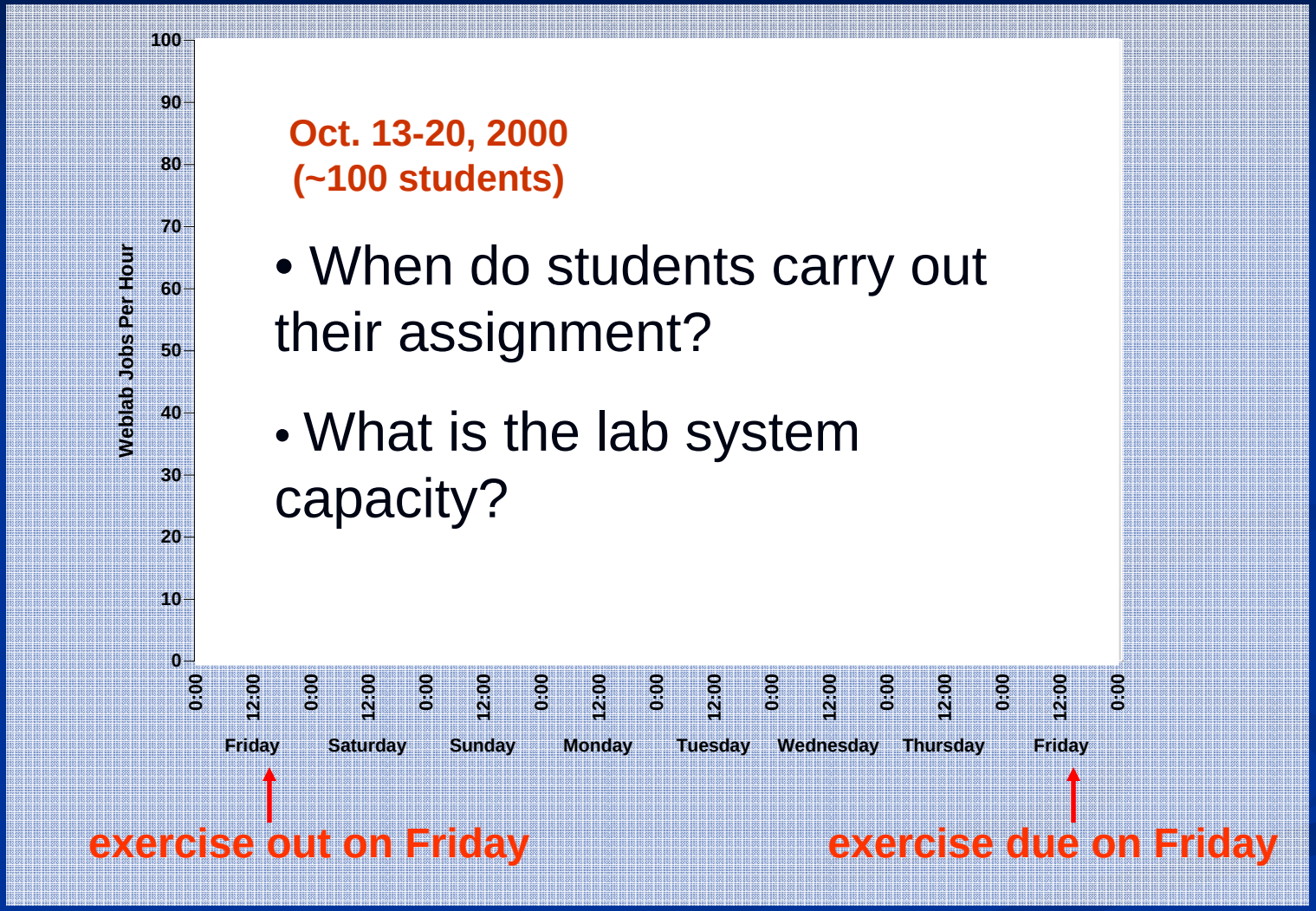
Transistor characterization project:

- Measure transistor characteristics
- Extract transistor parameters
- Compare measurements with class models

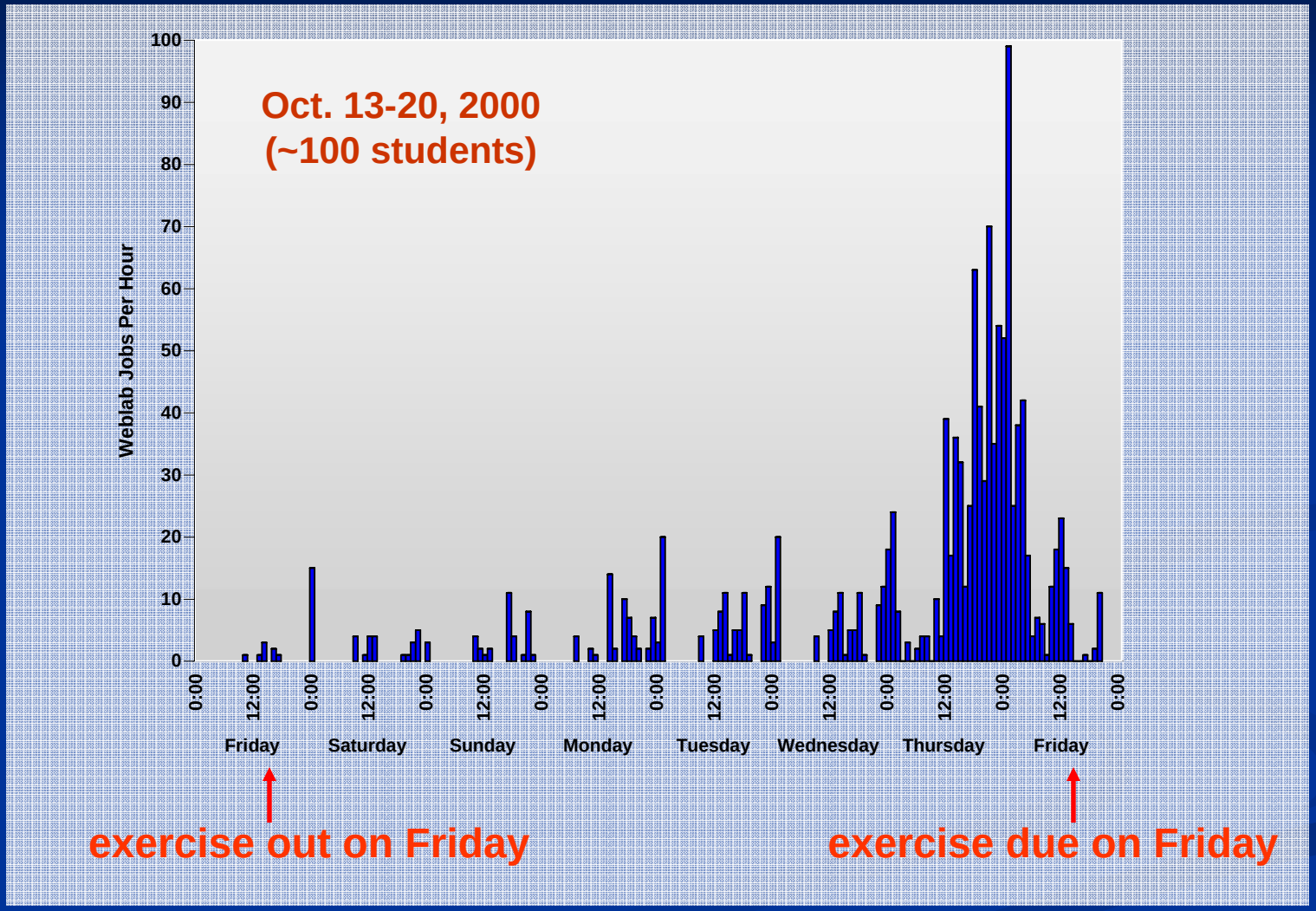


- Also, do whatever else you want with the transistor…

iLab Capacity

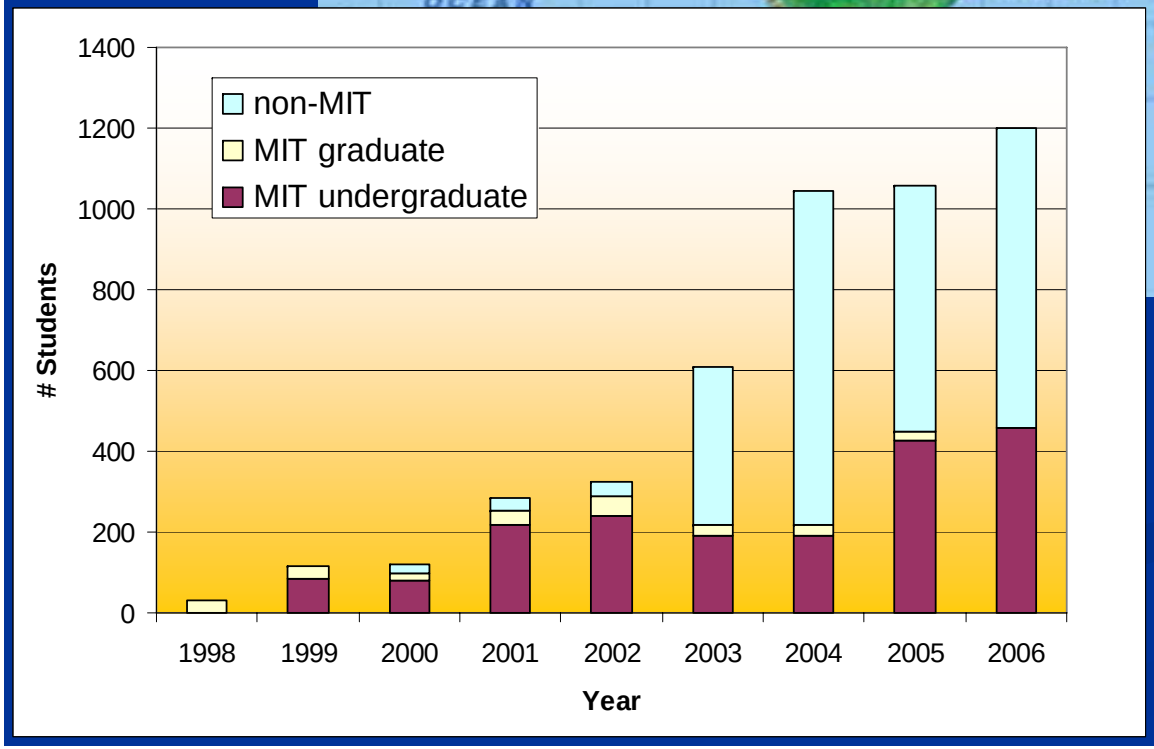


iLab Capacity



System capacity: > 2,000 users/week > 15,000 experiments/week

iLab Use



over 5400 student users (for credit) since 1998 from 4 different continents

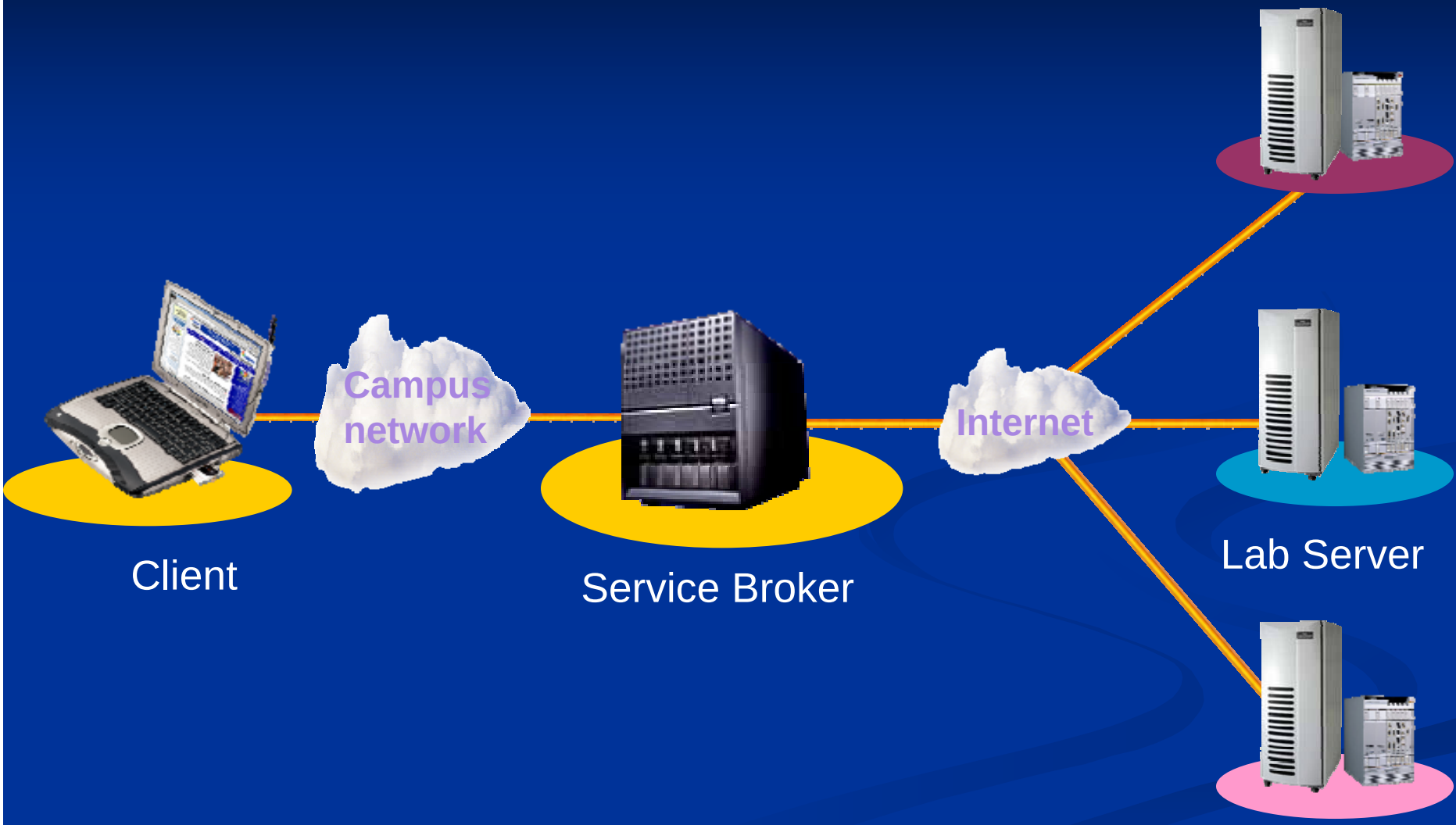
iLab: the Opportunities

- Order of magnitude more laboratories available to our students
- Unique labs:
  - Unusual locations, expensive equipment, rare materials
- Rich pedagogical experiences:
  - More lab time available to students
  - GUI to lab integrating graphing, simulation, collaboration, tutoring
- Worldwide communities of scholars created around labs sharing content

iLab: the Challenges

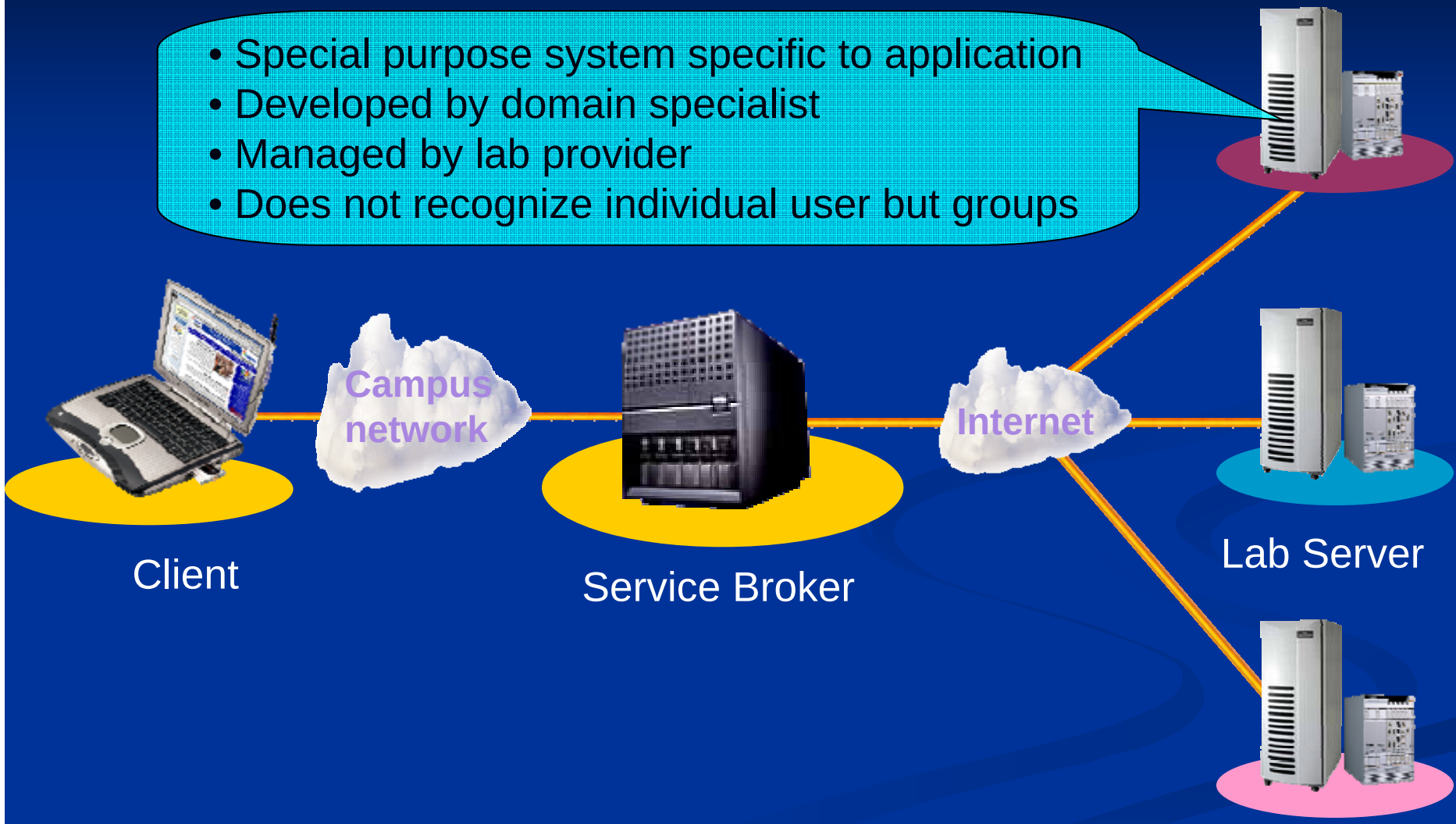
- Developing an iLab from scratch is a lot of work!
  - Great attention needed to user scalability
  - Needs to be done by domain specialist
- Managing a broadly shared iLab is also a lot of work!
  - Disincentive for owner to share lab
- Key challenge: iLab Scalability

The MIT iLab Architecture



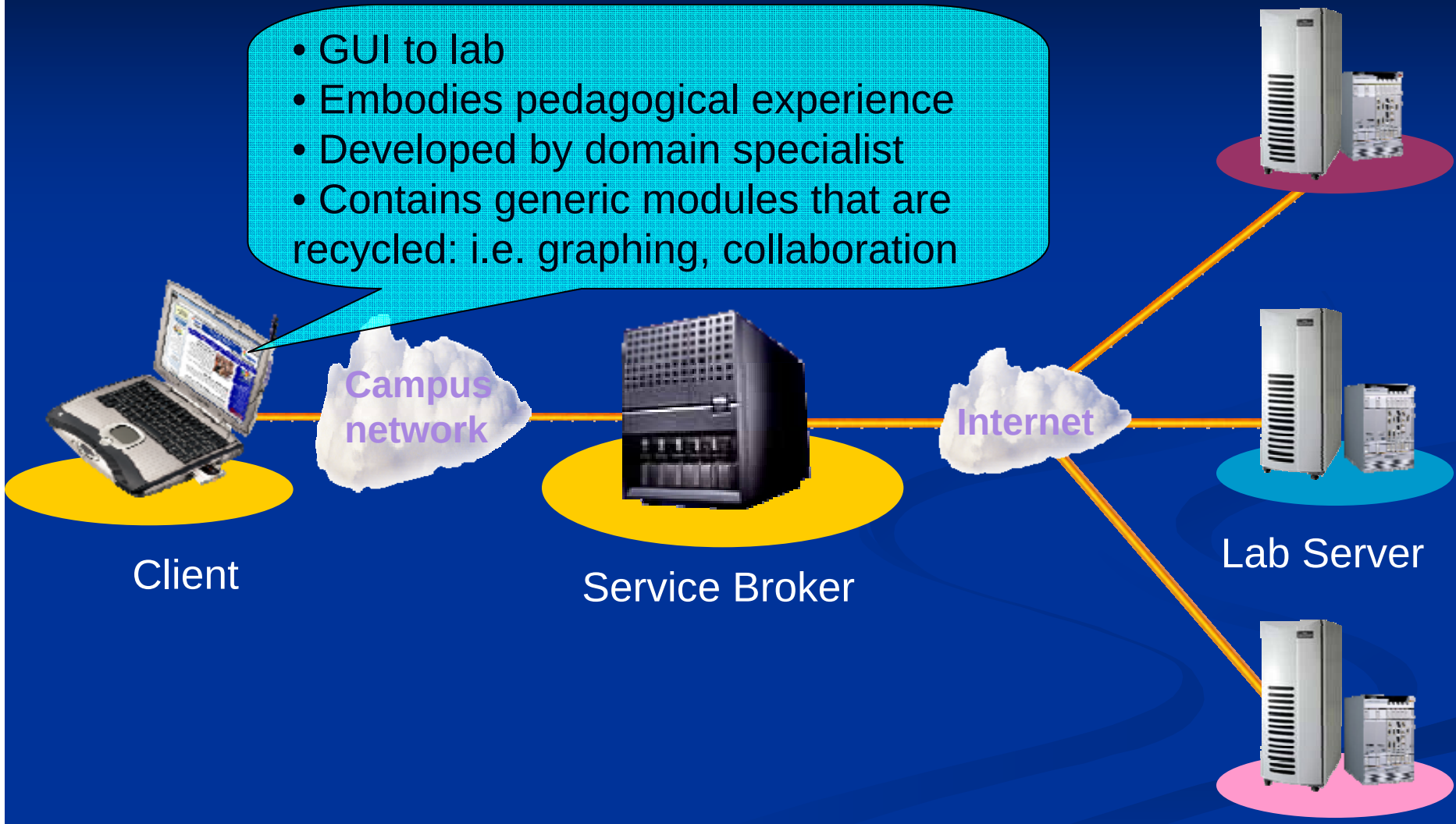
The MIT iLab Architecture

- Special purpose system specific to application
- Developed by domain specialist
- Managed by lab provider
- Does not recognize individual user but groups

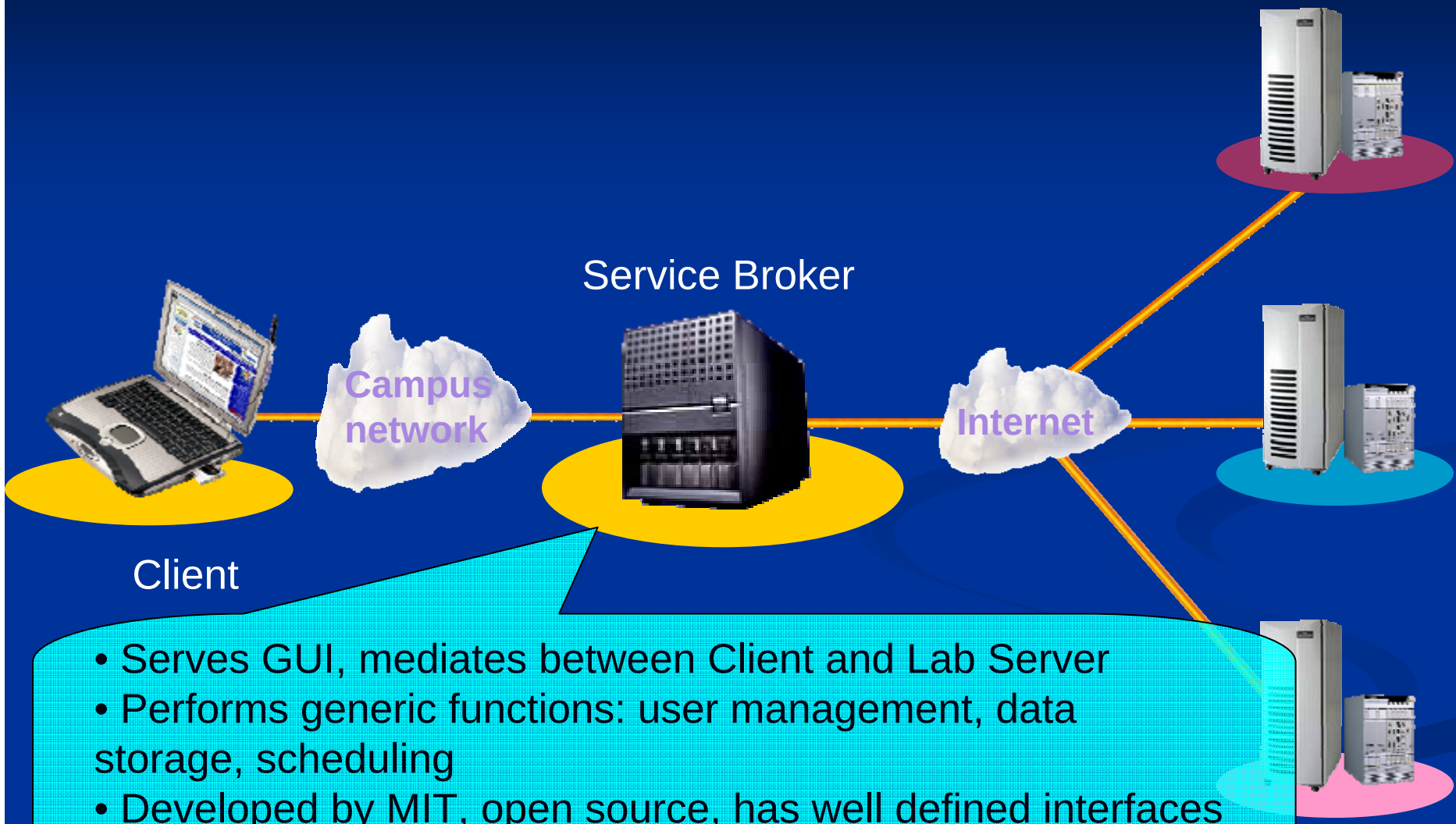


The MIT iLab Architecture

- GUI to lab
- Embodies pedagogical experience
- Developed by domain specialist
- Contains generic modules that are recycled: i.e. graphing, collaboration



The MIT iLab Architecture



- Serves GUI, mediates between Client and Lab Server
- Performs generic functions: user management, data storage, scheduling
- Developed by MIT, open source, has well defined interfaces
- Managed by end-user institution

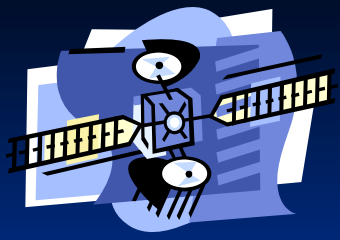
Service Brokers Around the World: nucleus for iLab development

Unique Issues for iLabs in developing countries

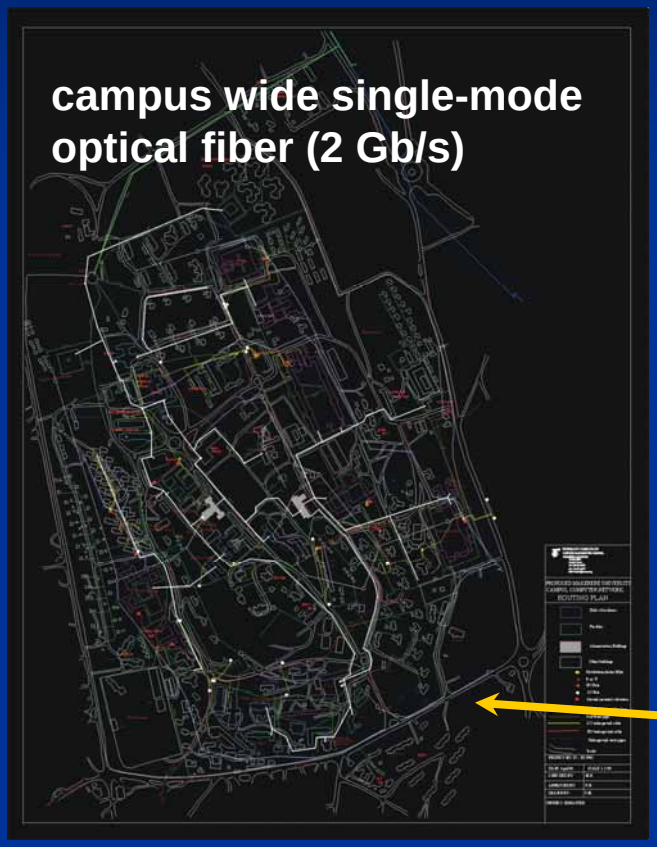
- Opportunities:
  - Paucity of labs
  - Great need for engineers
- Challenges:
  - Limited access to networked computers and educational software tools
  - Limited appreciation of versatility of computer
  - Severe bandwidth limitations

Bandwidth limitations

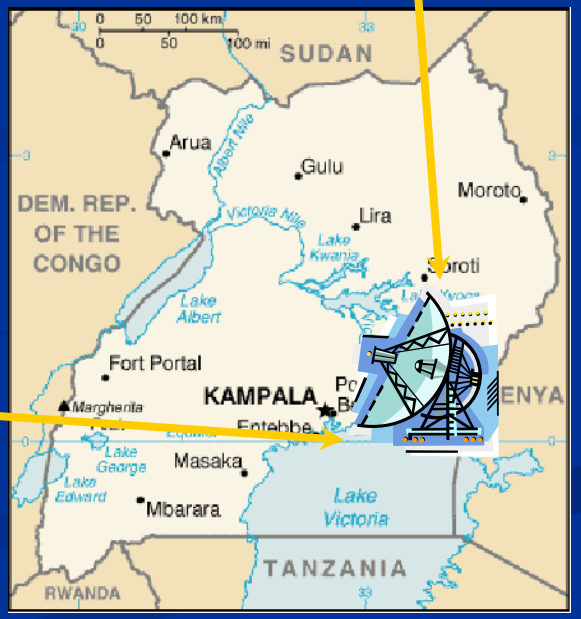
(example: Makerere University, Kampala)



satellite gateway to Internet



metropolitan network (total campus bandwidth=21 Mb/s)



academic buildings networked at 10/100 Mb/s

For comparison, MIT's bandwidth is 8 Gb/s (all data for Nov. 2006)

World Submarine Optical Fiber Systems

- Limited reach of optical fiber systems
- Limited national networks
- Similar problems in other regions in the World

Consequences for iLabs
(and other rich educational resources)

- Need to deploy educational resources ***locally***
- Solutions engineered in the developed world not necessarily effective across digital divide

  → need to engage developing countries in educational technology innovation

- Pedagogy likely to be different in bandwidth starved situations

  → need to be ready to experiment and modify

iLab-Africa project

Carnegie Corporation of New York

MAKERERE UNIVERSITY

University of Dar es Salaam

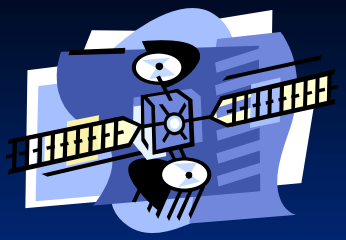
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Obafemi Awolowo University

- Goals:
  - To deploy iLabs throughout curriculum in Africa
  - To foster new iLab development in Africa

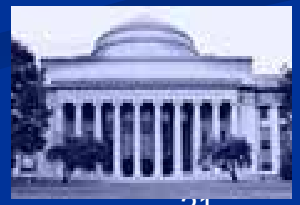
Local Service Brokers

Installed at OAU, MUK and UDSM



applet delivered by local service broker

student results stored locally



Average Applet download time at OAU reduced from 79” to 22”

Use of MIT iLabs from Africa

- Use of MIT Microelectronics Device Characterization iLab by African partners in 1st year:
  - 324 students from OAU
  - 89 students from UDSM
  - 289 students from MUK

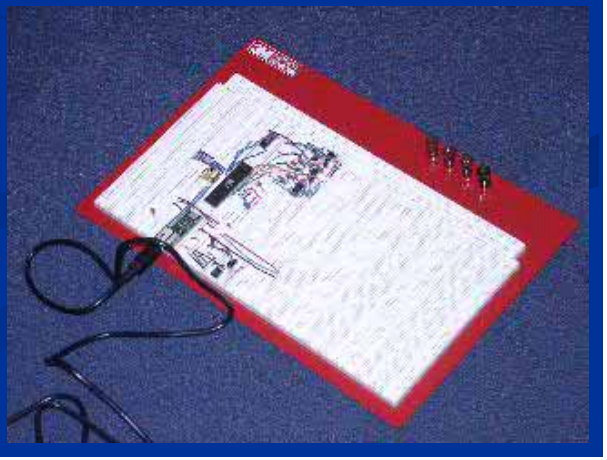
Investigating inexpensive hardware

Agilent 4155
~$40K

NI Elvis
~$2K

ELVIS iLab now at UDSM and OAU, soon at MUK

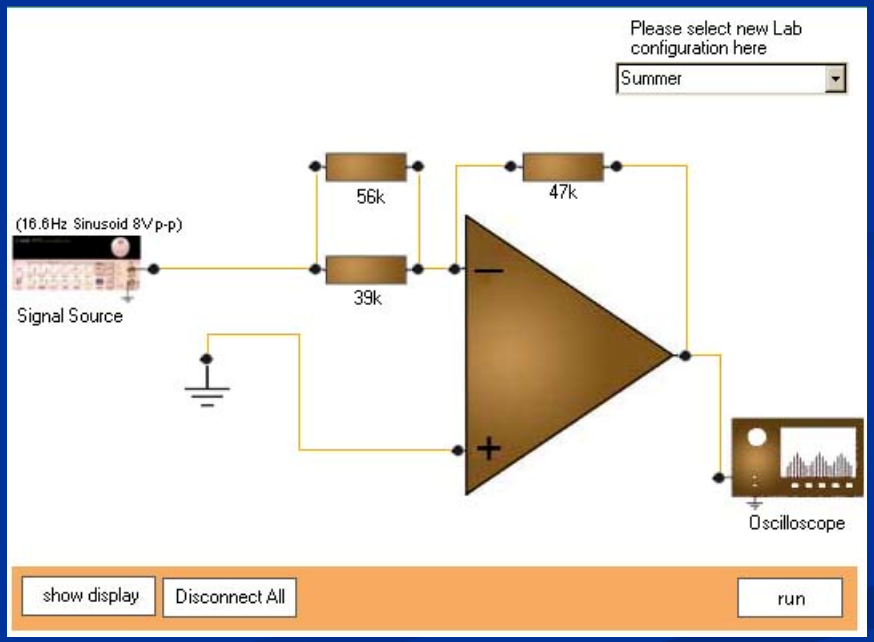
MIT “hack”
<$50

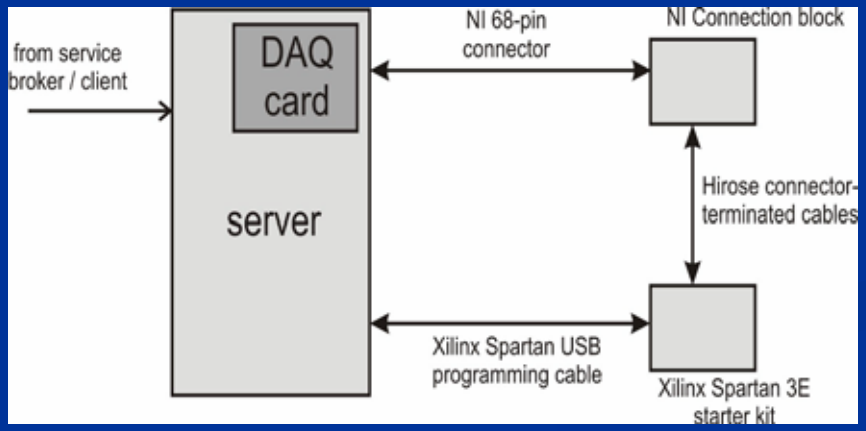


iLab development in Africa

Kayode Ayodele

OAU Opamp iLab





Future Directions for iLabs

- Expanding range of experiments
- Extending the iLab Architecture
- The iLab Consortium

Expanding the range of experiments

- Expanding experiments at MIT
  - DSA v3 featuring control system
  - ELVIS v2 with switching matrix
  - Nuclear diffraction experiments at MIT Nuclear Reactor
- New experiments at partner universities:
  - Beam Balancing Control Experiment and others (U. Queensland, Australia)
  - Refrigeration System (Dalian University, China)
- Training new iLab developers:
  - iLab Worksops at MIT (2005), Beijing (2006), Nigeria (2008)

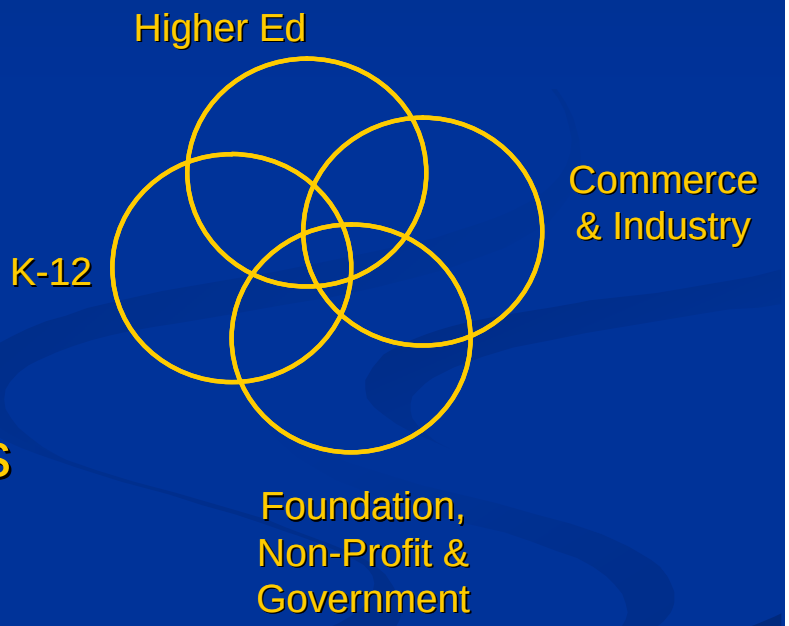
Extending the iLab Architecture: iLab experiment typology

- Batched Experiments (2003-2005):
  - Experiment completely specified before execution begins
  - Experiment executes on “machine time scale”
  - User need not remain online while experiment executes
- Interactive Experiments (2004-2007):
  - User can interact with experiment throughout its course
  - Experiment executes on “human time scale”
- Sensor Experiments (??):
  - Experiment is “always on” transmitting data
  - Experiments consist on
    - mining through data records
    - creating triggers and event-driven data monitoring

Sustainability-
The iLab Consortium

Need for an iLab Consortium:

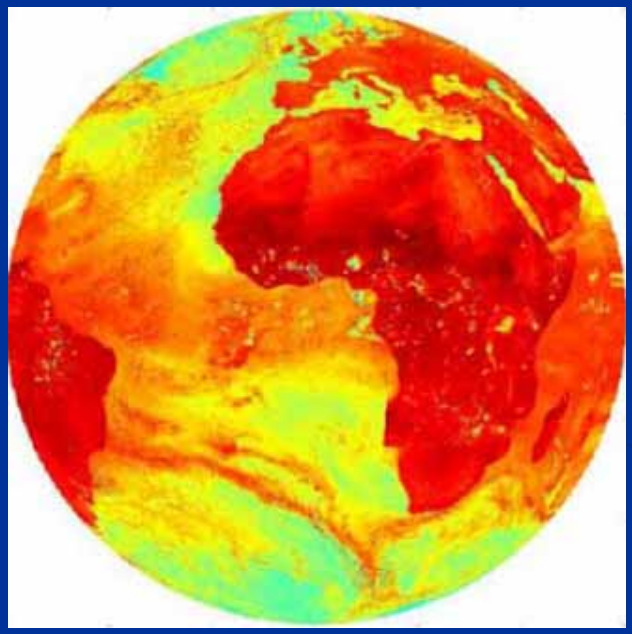
- to create an efficient market place for sharing and trading access to iLabs
- to support communities of scholars created around iLabs
- to lead evolution of iLab Architecture



Conclusions

- iLabs will enhance science and engineering education
- iLabs and their educational content will be broadly shared around the world
- iLabs can provide a path for the developed world to support education in the developing world
- iLab Architecture: scalable framework to support iLab dissemination around the world

“If You Can’t Come to the Lab… the Lab Will Come to You!”



(Earth at 89 GHz; courtesy of J. Grahn, Chalmers U.)